CHAPTER 7

MAINTENANCE OF GROUNDING AND BONDING SYSTEMS

7-1. Purpose of maintenance of grounding and bonding systems

Well designed and properly installed grounding, bonding, shielding, and lightning protection networks in a new facility or in an existing facility can rapidly deteriorate unless adequate and thorough maintenance is performed at regular intervals throughout the life of the facility.

7-2. Configuration control

Baseline records are of utmost importance when performing maintenance activities. The initial installation records should be maintained in such a fashion that they could be easily obtained for future reference.

a. New installations. In a new facility, consider the initial checkout as the first maintenance inspection for the facility. Utilize the results or information provided by the initial facility inspection as a base or starting point of comparison of the results of subsequent inspections. Subsequent inspections should be performed at least annually. In addition, a thorough inspection should be performed on affected parts or elements of the networks following major changes or additions to the facility either of the structure itself or of the equipment or systems located in the structure.

b. Existing facilities. In an older facility, consider the initial survey evaluation as the initial maintenance inspection. If a survey has not been made, an initial inspection of the facility should be made to determine the general condition of grounding networks, bonds, shields, and lightning protection subsystems. Subsequent to the survey or initial inspection, a maintenance inspection should be conducted annually and after major changes or additions to the facility as discussed above.

c. System modifications. Modifications of the facility system and the impact to the grounding system as a result of these modifications should be documented on the engineering drawings so that future maintenance activities can include the additions.

7-3. Maintenance and repair records

Chronological records of all tests and observations should be maintained. When a significant departure from the record is noted, an investigation should be performed to determine the cause and the necessary corrective action taken. Any measurement (i.e., earth electrode subsystem resistance, bond resistance, point-to-point ground network resistance, etc.) not meeting the specified or recommended value should be immediately investigated to see if rework is desired.

a. Facility maintenance report. Maintenance procedures for the earth electrode subsystem, lightning protection subsystem, signal reference subsystem, fault protection subsystem, facility ground system, bonding, and shielding should be prepared. Upon completion of any or all of these procedures, the facility maintenance report should be prepared and then placed in the permanent maintenance file or record along with other supporting evidence such as test results, photographs, and drawings. The facility

maintenance report should be reviewed and updated annually along with any supporting maintenance inspection or testing results.

b. Major deficiency report. Where deficiencies are noted that are immediately correctable (e.g., broken or misplaced bond wires or jumpers, loose bolts or screws, or other minor defects), they should be corrected with appropriate notation made on the facility maintenance report. A major discrepancy report should be made on major deficiencies (e.g., earth electrode resistance too high, parts of structure outside the cone of protection, excessive current levels on signal ground conductors, etc.) to identify those areas needing significant rework or upgrading.

7-4. Earth electrode subsystem

Proper maintenance of the earth electrode subsystem requires the following inspection and testing activities be performed at regular intervals.

a. Visual and mechanical inspection. The earth electrode subsystem should be visually inspected every 2 months and mechanically inspected every 12 months per InterNational Electrical Testing Association's (NETA) guidelines.

(1) Inspect all accessible portions of the system. Particularly look for loose connections, corrosion, and physical damage.

(2) Check the general overall condition of bonds as excellent, good, or poor. Perform resistance measurements and record the location of those that measure greater than one milliohm. (Take photographs as necessary to show nature of problems for before and after comparisons and for historical documentation purposes.)

(3) Note any undocumented changes or modifications to system. Update drawings as needed and correct minor deficiencies (e.g., clean surfaces, retighten or replace connectors and fasteners, reapply protective coatings, etc.).

(4) Generally inspect facility site for changes (in vegetation, roads, parking areas, excavation, drainage, etc.) that could cause future earth resistance variations and note such changes.

(5) Major deficiencies should be the subject of a major discrepancy report. After major deficiencies are corrected, the facility should be re-inspected. File the inspection report.

b. Electrical testing. Electrical testing of the earth electrode subsystem should be conducted every 24 months per NETA guidelines.

(1) Measure the resistance to earth of the earth electrode subsystem using the fall of potential method. Test directly in a ground well if available. If not, connect to a signal ground cable, the power system grounding conductor, a lightning down conductor, or a structural grounding connection.

(2) Measure stray current in grounding conductor between service disconnecting means and earth electrode subsystem (current reading).

(3) Concurrently with or following the visual inspection of the bonds, perform bond resistance measurements. Select five to ten bonds that visually appear tight, well made, and corrosion free and measure their resistances. The sampling should include structural bonds, equipment-to–structure bonds, connections between safety ground wires, conduit-to-conduit or conduit-to-cabinet joints, bonds in

lightning down conductors (to include structural columns if used for lightning discharge paths), and others as appropriate. Measure all bonds exhibiting visible defects. These measurements indicate the actual resistance between the two measurement points and also include the effects of any paths in parallel with the bond under test. For every bond exhibiting a resistance greater than one milliohm, check for looseness; if the connection is loose, tighten the fastener. Measure the resistance again after tightening. If the resistance is still greater than one milliohm and the joint can be readily disassembled, disassemble the joint and check for corrosion, debris, paint, or other non-conductive materials. Remove the material, reassemble the bond, and re-measure the resistance. If the resistance is still greater than one milliohm, note on the survey form the location of the bond and indicate the type of corrective action needed.

7-5. Fault protection subsystem

Proper maintenance of the fault protection subsystem requires the following inspection and testing activities be performed at regular intervals.

a. Visual and mechanical inspection. The fault protection subsystem should be visually inspected every 2 months and mechanically inspected every 12 months per NETA guidelines.

(1) Inspect all electrical/electronic equipment for safety grounding conductors (green wire). Check to see that sizes conform to all designated requirements.

(2) Spot check all green wire connections to see that they are tight and free of corrosion.

(3) Check inside equipment, switch boxes, and distribution panels to see that the white wire (neutral) is not grounded at these locations.

(4) Check the grounding connection at the first service disconnect to make sure it is tight and free of corrosion.

(5) Generally check the electrical supporting structures for looseness in joints or bonds and evidence of corrosion.

b. Electrical testing. Electrical testing of the fault protection subsystem should be conducted every 24 months per NETA guidelines.

(1) With neutral disconnected at first service disconnect, the resistance to ground should be at least one megohm. (New ground resistance testers on the market today do not require that the neutral conductor be disconnected.)

(2) Perform spot check resistance measurements on power receptacles and stray current measurements on safety ground to insure that the ground terminals on the receptacles are properly grounded to the facility ground system and no currents are flowing on grounding conductor.

(3) Measure for stray currents at obvious locations.

(4) Perform resistance tests of a sample of bonds as described earlier in this chapter

7-6. Lightning protection subsystem

Proper maintenance of the lightning protection subsystem requires the following inspection and testing activities be performed at regular intervals.

a. Visual and mechanical inspection. The lightning protection subsystem should be visually inspected every 2 months and mechanically inspected every 12 months per NETA guidelines.

(1) Verify that all facility components and antennas are within the cone of protection.

(2) Check for evidence of burning and/or pitting, as well as melting of air terminals.

(3) Check for burned fasteners.

(4) Check for broken or melted down conductors or severely damaged as well as distorted roof conductors, down conductors, and bonding jumpers.

(5) Look for signs of arcing or flashover indicating a need for bonding jumpers or spark gaps.

(6) Check for corroded or loose connectors and fasteners.

(7) Verify that copper-to-aluminum contact does not occur except through Underwriters Laboratories (UL) approved bimetallic connectors.

(8) Verify that all guards for down conductors are in place and without severe mechanical damage.

(9) Verify that all guards are bonded to down conductors (at both ends of guard).

b. Electrical testing. Bond resistance tests of a sample of bonds as described earlier in this chapter should be conducted every 24 months per NETA guidelines.

7-7. Signal reference subsystems

Proper maintenance of the signal reference subsystems requires the following inspection and testing activities be performed at regular intervals.

a. Visual and mechanical inspection. The signal reference subsystem should be visually inspected every 2 months and mechanically inspected every 12 months per NETA guidelines.

(1) Inspect connections to equipment signal ground terminals and equipotential plane for looseness and corrosion. Apply corrective measures.

(2) Check to see if any new equipment has been added or relocated since the last inspection. If so, check interconnecting cables for conformance with the requirements.

(3) Ensure that labels and protective covers are in place and free of serious damage.

(4) Inspect equipment grounding cables for correct sizes, physical damage, and properly bonded end connections.

b. Electrical testing. Electrical testing of the fault protection subsystem should be conducted every 24 months per NETA guidelines.

(1) Perform resistance tests of a sample of bonds as described earlier in this chapter.

(2) Perform point-to-point resistance measurements at select locations comprising approximately 25 percent of available locations.

(3) Perform stray current measurements and differential noise voltage measurements.

7-8. Facility shielding

Proper maintenance of the facility shielding requires the following inspection and testing activities be performed at regular intervals.

a. Visual and mechanical inspection. The signal reference subsystem should be visually inspected every 2 months and mechanically inspected every 12 months per NETA guidelines.

(1) Check personnel barriers for mechanical strength, signs of damage, and proper grounding (if metallic).

(2) Insure that all shields around high voltage apparatus are properly labeled. Labels should be provided in accordance with the individual facility standards, practices and requirements.

(3) Check electromagnetic (EM) shields for adequate bonding.

(4) Inspect all EM shields for holes or openings added since last inspection. Check to see that such openings are properly covered with screening or covers.

(5) Inspect power line and signal line filters on wires entering shielded areas for proper peripheral grounding.

(6) Inspect cable shield pigtails for excessive length.

(7) Inspect connectors for tightness, evidence of corrosion, or physical damage.

(8) Ensure that all grounding conductors penetrating a designated radio frequency (RF) barrier are peripherally bonded to barrier.

b. Electrical testing. Bond resistance tests of a sample of bonds as described earlier in this chapter should be conducted every 24 months per NETA guidelines.

7-9. Performance evaluation program

The purpose of the performance evaluation program is to provide checklists and procedures for the evaluation of compliance to overall grounding, bonding, and shielding practices. Individuals qualified in the proper methods of obtaining an acceptable grounding system accomplish the evaluation mainly through visual inspection. Checklists should be prepared to include the following attributes for inspection.

a. Resistance to earth of the earth electrode subsystem should be less than 10 ohms.

b. The lightning down conductors should be continuous and welded or brazed to the earth electrode subsystem.

c. Underground metal pipes entering the facility should be bonded to the earth electrode subsystem.

d. The fall-of-potential method should be used to measure the earth electrode subsystem.

e. A separate grounding conductor (green wire) should exist for the power system and be installed with the phase and neutral conductors.

f. Document if conduit is used in lieu of the separate grounding conductor.

g. All non-current carrying metal objects should be grounded. All main metallic structural members, electrical supporting structures, metallic piping, tubing, and supports should be electrically continuous and grounded.

h. The alternating current (ac) grounded conductor (neutral) should be grounded only at the source distribution transformer and at the service entrance to the earth electrode subsystem.

i. All generators and their frames should be grounded. Generator neutrals should be tied together and grounded by a single lead to the earth electrode subsystem.

j. The ground terminals of all ac outlets should be connected to the facility ground system through the grounding (green) conductor.

k. One leg of each direct current (dc) power system should be grounded.

l. The facility should be protected against lightning.

(1) All antennas should be inside a 1:1 cone of protection.

(2) Bends in down conductors of the lightning protection subsystem should have a radius of at least 20 cm (8 inches) and not less than 90°.

(3) Metal objects should not be within 1.8 meters (6 feet) of the lightning down lead.

(4) All bonds between elements of the lightning protection subsystem should be welded, brazed, or secured by UL approved clamps.

m. If the facility has a metal tower, it should have a direct tie to the earth electrode subsystem with the down conductors bonded to the tower at the base. If in conduit, the conduit should be bonded at each end.

n. The waveguide should be grounded near the antenna, at the vertical to horizontal transition, and at the waveguide entry port.

o. All metal hand rails, ladders, stairways, antenna pedestals, and other objects subject to human contact should be grounded.

p. Power lines at the point-of-entry to the facility should be protected with approved lightning arresters.

q. Overall cable shields should be grounded at each end.

r. Bonds should show no signs of corrosion, should be adequately torqued, and be low in resistance.

s. The routing and layout of power lines and high level signal lines must be kept separate from low level signal lines.

t. The equipotential plane should be bonded to the facility ground earth electrode subsystem.

u. Resistance measurements should be conducted on the equipotential plane.

v. Ground-fault-circuit-interrupters (GFCI) should be installed on 15 and 20 ampere convenience outlets.